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Effectiveness of an economic adsorbent in the adsorption of methylene blue from an industrial dyeing effluent

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ABSTRACT

An low-cost and eco-friendly activated carbon from the fruits of Mimusops Elengi (Makhizam Poo) has been used in this study to remove methylene blue from an industrial dyeing effluent . The effect of variation of initial concentration of dye solution on the adsorption of dye from an industrial effluent, the optimum contact time for effective adsorption of dye has been studied and compared with that of commercially available activated carbon. The applicability of adsorption isotherms to study the adsorption behaviour has also been analyzed. An increase in the percentage removal of methylene blue from 35.7 to 63.3% with ACM in 180 minutes of agitation time was noted when the initial concentration of methylene blue obtained from a dyeing industrial effluent was varied from 1000 to 600mg/L. The favourable value of R_L in the Langmuir adsorption data shows the feasibility of the adsorption process.

Keywords: methylene blue. Adsorption , effluent, Langmuir isotherm, *Mimusops elengi.*

INTRODUCTION

Dye-bearing wastes impose a serious threat to the surrounding environment matrix by creating imbalance in the aquatic eco-system by disturbing the symbiotic equilibrium (Venkatamohan et *al.*, 2003). Many dyes have toxic effect as well as carcinogenic and mutagenic effects on aquatic life and also on humans (Mehmet *et al*., 2008). Many physical and chemical methods, such as coagulation, floatation, chemical oxidation, solvent extraction, hyper filtration etc have been tried in order to remove colour from wastewater (Jyoti rekha *et al.*, 2008). However all of these methods suffer from one or other limitations. Basic dyes are the brightest class of soluble dyes used by the textile industry (Dinesh *et al.*, 2002. Methylene blue is one of the most commonly used thiazine dyes and various adsorbents have been reported for its removal from aqueous solutions (Sathy *et al.*, 2006).

Methylene blue is an important basic dye widely used for printing calico, dyeing, printing cotton and tannin, indicating oxidation- reduction and dyeing leather and in purified zinc-free from it is used as an antiseptic and for other medicinal purposes (Gupta *et al.*, 2004). The present study is

aimed at using an low-cost and eco-friendly activated carbon from the fruits of *Mimusops Elengi* (Makhizam Poo) . The effect of variation of initial concentration of dye solution on the adsorption of dye from an industrial effluent, the optimum contact time for effective adsorption of dye have been studied. The applicability of adsorption isotherms to study the adsorption behaviour has also been analyzed.

MATERIALS AND METHODS

Preparation of the adsorbent

Fruits of *Mimusops Elengi* were collected from Avinashilingam University campus, Coimbatore. The pods of the *Mimusops Elengi* were cut into small pieces, dried in sunlight for 5 days and further dried in a hot air oven at 60°C for 24 hours. The completely dried material was powdered well. The powdered raw material was chemically activated by treating with concentrated sulphuric acid with constant stirring and kept for 24 hours. The carbonized material obtained was washed well with plenty of water several times to remove excess acid and dried at 105-110°C in a hot air oven for 24 hours. The adsorbent thus obtained was ground well and sieved through a 250 mesh and kept in an airtight container for further use.

Reagents

The dye solution was prepared by dissolving 5g of Methylene blue in distilled water and diluted to 1000ml. The stock solution was diluted to appropriate concentration.

Equipment

- Elico pH meter was used to measure pH.
- Photo colorimeter (model-1311) was used for spectro colorimetric work.
- Genuine mechanical horizontal bench shaker was used for the shaking of solution containing adsorbent and adsorbate.

ANALYTICAL PROCEDURES

Characterization of the adsorbents

Physical characteristics namely ash content (%), moisture content (%), pH, surface area, bulk density, specific gravity and porosity (%) of the adsorbents used in this study were determined to identify the applicability of these adsorbents to remove Methylene blue.

Ash content

One gram of carbon was weighed accurately into a tarred porcelain crucible. The crucible and its contents were placed in an electric oven at 110 $\pm 5^0$ C for 5 hours. The crucible was removed from the oven and it was ignited in an electric muffle furnace at a temperature of 800^0C for 2 hours. The process of heating and cooling was repeated until the difference between two consecutive weighing was less than 1 mg .

$$\text{Ash (on dry basis) percent by weight} = \frac{M_1}{(M_2\text{-}X)} \times 100$$

where

M_1 = Weight of ash (g)

M_2 = Weight of adsorbent taken for test (g)

X = Percentage of moisture content present in the material taken for test.

pH

Fifteen grams of the carbon was weighed, added 300ml water (adjusted to pH 7.0) and heated to boiling. After digesting for 10 minutes, it was filtered and the first 50ml of the hot filtered was decanted. The remaining filtrate was cooled to room temperature and the pH was determined.

Moisture content

About 5g of the carbon was weighed accurately in a petridish. The dish was placed in an electric oven maintained at 110 $\pm 5^0$ C for about 5 hours after which it was cooled in a dessicator and then weighed. Heating, cooling and weighing was repeated at 30 minute interval until the difference between the two consecutive weighing was less than 5mg

$$\text{Moisture content (percent by weight)} = \frac{(M-X)}{M}$$

where

M = Weight of the adsorbent taken for test (g)

X = Weight of the adsorbent after drying (g)

Surface area (Acetic acid adsorption method)

Two hundred milligrams of the adsorbent was weighed accurately and taken in a serious of Pyrex bottles containing 50ml of 0.01, 0.02, 0.03, 0.04 and 0.05 M acetic acid and a control was also prepared for each concentration without adsorbent. The bottles were tightly stoppered and kept in a horizontal electrical bench shaker and agitated for one hour. The samples were separated by filtration using Whatmann 42 filter paper. The filtrates were titrated against standard sodium hydroxide solution using phenolphthalein as an indicator to find out the remaining concentration of the acetic acid. The concentration of acetic acid remaining in each instance (C) is divided by the number of moles of acetic acid adsorbed per gram (N) of the adsorbent to get the ratio of C to N. A plot of C/N versus C (the concentration of acetic acid remaining) was made. A straight –line plot was obtained. The reciprocal of the slope of the linear plot of C/N versus C gives the number of moles of acetic acid required per gram to form a monolayer (N_m). Substituting the N_m value in the following equation, surface area, A (m^2/ g) was calculated for the adsorbent**.**

$$\mathbf{A = N_m \times N_0 \times \sigma \times 10^{20}}$$

where,

N_m = Number of moles of acetic acid per gram of the adsorbent required to form mono layer

N_0 = Avogadro number

σ = Molecular cross sectional area assumed for acetic acid in square Angstroms 21^0 A^2 for acetic acid.

Bulk density

For the determination of bulk density a 50ml graduated cylinder was weighed and a trip balance was used to fill the carbon in the cylinder. Sufficient amount of the carbon was poured with constant tapping and filled to the 50ml mark. The shaker attached to the balance was adjusted, so that the carbon fills the graduated cylinder at approximately 1ml per second. After filling the graduated cylinder with carbon, it was weighed accurately. The bulk density was calculated by dividing the weight of carbon by 50.

Specific gravity

Five grams of oven-dried carbon sample was placed in a small porcelain dish with 50ml of distilled water and the contents were heated to boiling gently for 3 minutes to expel the air. After cooling in a water bath to 15^0 C the carbon suspension was transferred to a 100ml –pyconometer

with the help of a small funnel, a wire and a wash bottle. The pyconometer was filled with water and stoppered, taking care not to leave any air bubbles in the container. The pyconometer was dried with a piece of cloth and weighed.

$$\text{Specific gravity} = \frac{\text{Weight of adsorbent (Wa)}}{\text{Volume of displaced water (V)}}$$

$$\text{where } V = \frac{Wa+Wb+Wc}{\text{Density of water}}$$

Wb =Weight of Pyconometer with water(g)
Wc = Weight of Pyconometer with adsorpbent suspension(g)

Porosity

Porosity was determined from the specific gravity (S) and bulk density (D) values of carbon by applying the following formula:

$$\text{Porosity} = \frac{S-D}{S} \times 100$$

Batch experiments

Batch mode experiments were carried out to study the adsorption capacities of the adsorbent (ACM) and compared with that of commercial activated carbon adsorbent (ACC). Though industrial operations are not carried out batch- wise, these are simple and effective in evaluating the basic parameters affecting adsorption process. In batch mode adsorption study, a very good contact occurs between the Methylene blue species and carbon by shaking at 150rpm (rotation per minute) speed. Experiments were performed in duplicate.

Study of adsorption potential of dye from dyeing industrial effluent using the adsorbents ACM and ACC- variation of concentration of dye and time of adsorption

Experiments were performed with 100mg of the adsorbent ACM by varying the initial concentration of Methylene blue (600, 800and 1000mg/L) prepared from a dyeing industrial effluent. Similarly experiments were performed with 50mg of the adsorbent ACC by varying the initial concentration of Methylene blue (600, 800and 1000mg/L) prepared from a dyeing industrial effluent. These solutions were taken in a temperature controlled horizontal electrical bench shaker and agitated for various time intervals (10, 20, 30, 40, 50, 60, 90, 120, 150 and 180 minutes). The adsorbate and the adsorbents were separated and analyzed colorimetrically.

Scanning Electron Microscope (SEM) analysis

The SEM photographs of the following were obtained

- The adsorbent prepared from pods of *Mimusops Elengi* (ACM)
- Adsorbent (ACM) with the adsorbed Methylene species from an dyeing industrial effluent,

RESULTS AND DISCUSSION

Characteristics of the adsorbents

The results of the physical characteristics of the adsorbents used in the study are given in Table 1.

TABLE 1: Characteristics of the adsorbents

Parameter	Adsorbents	
	ACC	ACM
Ash content (%)	0.3860	6.32
Moisture content (%)	17.44	7.42
pH	6.57	3.60
Surface area (m^2/g)	710	340
Bulk density (g/cc)	0.2450	0.603
Specific gravity(g/cc)	0.9128	0.615
Porosity (%)	72.35	35.26

Effect of variation of initial concentration of effluent and contact time of adsorption on the adsorption potential of an economic adsorbent

The initial concentration of effluent was varied and batch mode experiments were performed at 32^{o}C and at pH 6.7±0.02 to study the effect of variation of initial concentration of effluent (600,800 and 1000mg/L) on methylene blue removal . The results are given in tables 2 and 3. The time of adsorption was also varied from 10 to 180 minutes as in the table.

TABLE – 2: Effect of initial concentration of methylene blue from dying industrial effluent for the adsorption of methylene blue onto ACM

Conditions: Adsorbent dosage- 100mg ; pH -6.7 ±0.02
Contact time -10 to180 minutes

Time (minutes)	% Adsorption of Methylene blue		
	Initial concentration (mg/L)		
	600	800	1000
10	47.9	42.1	21.4
20	51.0	44.6	23.5
30	52.0	45.9	24.5
40	55.1	47.2	26.5
50	57.1	48.5	27.6
60	58.2	49.7	29.6
90	61.2	52.3	31.6
120	62.2	54.8	33.7
150	63.3	54.8	34.7
180	63.3	54.8	35.7

TABLE – 3: Effect of initial concentration of methylene blue from dying industrial effluent for the adsorption of methylene blue onto ACC

Conditions: Adsorbent dosage- 50mg; pH - 6.7±0.02
Contact time - 10 to180 minutes

Time in minutes	% Adsorption of Methylene blue		
	Initial concentration of Methylene blue (mg/L)		
	600	800	1000
10	78.4	64.0	61.2
20	81.5	68.0	64.3
30	83.0	70.7	66.3
40	86.1	73.3	68.4
50	89.2	74.7	71.4
60	90.7	77.3	72.4
90	92.3	80.0	73.4
120	95.3	81.3	76.5
150	95.3	82.6	77.5
180	95.3	82.6	78.5

It is well evident from the results that the percentage removal of methylene blue from the dyeing effluent increases with decrease in the in the initial concentration of effluent in the case of both the adsorbents. An increase in the percentage removal of methylene blue from 35.7 to 63.3 (Table 2) with ACM in 180 minutes of agitation time, when the initial concentration of methylene blue was varied from 1000 to 600mg/L was noted. The results of this study show that the removal of methylene blue is concentration dependent. This is obvious, since at higher initial concentration, a more efficient utilization of the adsorptive capacity of the adsorbent is expected due to higher driving force (Ho and Mckay, 1998). It was also noted that methylene blue adsorbed increased (48 to 63%) with contact time (10 to 180 min) at all concentrations of the effluent with ACM as adsorbent and 78% to 95% with commercially available carbon (Table 3). With ACC as adsorbent 95% adsorption was noted in 180 minutes with initial concentration of effluent being 600mg/L whereas 63% adsorption was noted for the economic adsorbent under similar conditions. This shows the potential of the economic adsorbent. Increasing the surface area of the prepared adsorbent would increase its adsorption potential.

Adsorption isotherms

It is important to have a satisfactory description of the equilibrium state between the two phases in order to successfully represent the dynamic behaviour of any adsorbate from solution to the solid (adsorbent) phase. Adsorption isotherm can be defined as a functional expression for the variation in adsorption of the adsorbate by the adsorbent in the bulk solution at constant temperature (Weber, 1972). The equilibrium isotherm is of fundamental importance for the design and optimization of the adsorption system for the removal of dye by adsorption. In the present study, two of the most commonly used models, namely Langmuir and Freundlich isotherms are studied for the adsorption of methylene blue. The distribution of adsorbate between the adsorbent and the bulk solution when the system is in equilibrium is important to establish the capacity of the adsorbent for adsorbing the adsorbate.

Langmuir adsorption isotherm

The Langmuir equation correlates the amount of adsorbate adsorbed with the equilibrium aqueous concentration.The linear transformation of the Langmuir adsorption isotherm (Rao and Bhole, 2001) is given as,

$$\mathbf{1/ (x/m) = 1/ b + 1/ab\ C_e}$$

where,

x = amount of Methylene blue adsorbed (mg/L)

m = Weight of adsorbent (g)

C_e = Concentration of Methylene blue at equilibrium in mg

'a' and 'b' are the Langmuir constants which are the measure of maximum energy of adsorption and adsorption capacity respectively.

The Langmuir adsorption isotherm data for Methylene blue adsorption from a dying industrial effluent on the adsorbents ACM and ACC are summarized in Tables 4 , 5 and 6, 7 respectively.

TABLE – 4: Langmuir adsorption isotherm for methylene blue adsorption onto ACM

Time in minutes	Initial conc.of dye mg/L	1/ Ce	m/x	Separation factor R_L	Intercept k_1/k_1^1	Slope $1/k_1^1$	Correlation coefficient (r)
10	**600** **800** **1000**	0.03205 0.01508 0.01274	0.3484 0.2967 0.4672	-0.00456 -0.00342 -0.00273	0.4251	-2.7248	-0.3284
20	**600** **800** **1000**	0.03412 0.01557 0.01307	0.3267 0.2801 0.4255	-0.00333 -0.00249 -0.00199	0.3857	-1.9897	-0.3082
30	**600** **800** **1000**	0.03484 0.01582 0.01326	0.3205 0.2724 0.4255	-0.00265 -0.00198 -0.00158	0.3674	-1.5862	-0.2718
40	**600** **800** **1000**	0.03717 0.01607 0.01362	0.3030 0.2652 0.3773	-0.00203 -0.00152 -0.00122	0.3423	-1.2197	-0.2769
50	**600** **800** **1000**	0.03891 0.01634 0.01381	0.2915 0.2577 0.3623	-0.00186 -0.00139 -0.00111	0.3295	-1.1161	-0.2889

TABLE – 5: Langmuir adsorption isotherm for methylene blue adsorption onto ACM

Time in minutes	Initial conc.of dye mg/L	1/ Ce	m/x	Separation factor R_L	Intercept k_1/k_1^1	Slope $1/k_1^1$	Correlation coefficient (r)
60	**600** **800** **1000**	0.04000 0.01661 0.01420	0.2865 0.2512 0.3378	-0.00096 -0.00072 -0.00058	0.3055	-0.5798	-0.1897
90	**600** **800** **1000**	0.04310 0.01782 0.01464	0.2724 0.2392 0.3164	-0.00075 -0.00056 -0.00045	0.2873	-0.4512	-0.1817
120	**600** **800** **1000**	0.04424 0.01782 0.01508	0.2680 0.2277 0.2967	0.00004 0.00003 0.00002	0.2634	0.0249	0.0115
150	**600** **800** **1000**	0.04545 0.01782 0.01531	0.2638 0.2277 0.2881	0.00011 0.00008 0.00006	0.2581	0.0675	0.0372
180	**600** **800** **1000**	0.04545 0.01782 0.01557	0.2638 0.2277 0.2801	0.00039 0.00029 0.00023	0.2509	0.2362	0.1466

TABLE – 6: Langmuir adsorption isotherm for methylene blue adsorption onto ACC

Time in minutes	Initial conc. of dye mg/L	1/ Ce	m/x	Separation factor R_L	Intercept k_1/k_1^1	Slope $1/k_1^1$	Correlation coefficient (r)
10	**600** **800** **1000**	0.07752 0.03472 0.02583	0.1063 0.0976 0.0816	0.00065 0.00048 0.00039	0.0771	0.3908	0.8622
20	**600** **800** **1000**	0.09090 0.03906 0.02801	0.1022 0.0919 0.0777	0.00055 0.00041 0.00033	0.0732	0.3299	0.9004
30	**600** **800** **1000**	0.09909 0.04273 0.02976	0.1004 0.0884 0.0754	0.00052 0.00039 0.00031	0.06997	0.3162	0.9323
40	**600** **800** **1000**	0.12048 0.04694 0.03164	0.0968 0.0853 0.0730	0.00039 0.00029 0.00023	0.0696	0.2326	0.9282
50	**600** **800** **1000**	0.15625 0.04950 0.03508	0.0934 0.0837 0.0700	0.00026 0.00019 0.00015	0.06992	0.1552	0.8720

TABLE – 7: Langmuir adsorption isotherm for methylene blue adsorption onto ACM

Time in minutes	Initial conc.of dye mg/L	1/Ce	m/x	Separation factor R_L	Intercept k_1/k_1^1	Slope $1/k_1^1$	Correlation coefficient (r)
60	**600**	0.18181	0.0919	0.00022	0.0686	0.1318	0.9103
	800	0.05524	0.0809	0.00016			
	1000	0.03636	0.0690	0.00013			
90	**600**	0.2173	0.0904	0.00018	0.0673	0.1085	0.9446
	800	0.06628	0.0781	0.00013			
	1000	0.03773	0.0681	0.00011			
120	**600**	0.3623	0.0874	0.00009	0.0678	0.0550	0.8852
	800	0.06711	0.0769	0.00007			
	1000	0.04273	0.0653	0.00005			
150	**600**	0.3623	0.0874	0.00009	0.0663	0.0592	0.9103
	800	0.07246	0.0756	0.00007			
	1000	0.04464	0.0645	0.00006			
180	**600**	0.3623	0.0874	0.00010	0.0657	0.0609	0.8982
	800	0.07246	0.0756	0.00007			
	1000	0.04672	0.0636	0.00006			

The Langmuir plots obtained by plotting $1/C_e$ Vs m/x are linear showing the applicability of Langmuir adsorption isotherm for methylene blue adsorption using both the adsorbents (ACM and ACC) used in this study. This is also evidence by the best fit of the linear equation as seen from the correlation co-efficient values 'r'. The essential characteristics of Langmuir adsorption isotherm can be expressed in terms of a dimensionless constant, separation factor or equilibrium parameter 'R_L'which is defined by,

$$R_L = \frac{1}{1+bC_i}$$

where, C_i = initial concentration of the dye in mg/L

b = Langmuir constant (k_1^1)

The parameter R_L indicates the shape of the isotherm as follows:

R_L value	Type of isotherm
$R_L > 1$	Unfavorable
$R_L = 1$	Linear
$0 < R_L < 1$	Favorable
$R_L = 0$	Irreversible

The values of the dimensionless equilibrium parameter R_L, reveal that the Langmuir adsorption isotherm is favorable for the adsorption of methylene blue with both the adsorbents (ACM and ACC) throughout the 180 minutes of adsorption study time.

Freundlich adsorption isotherm

The Freundlich adsorption isotherm equation is used for determining the applicability of heterogeneous surface energy in the adsorption process. The empirical Freundlich equation is

$$x/m = K_F Ce^{1/n}$$

$$\log x/m = \log K_F + 1/n \log Ce$$

where ,

x = amount of Methylene blue adsorbed in mg

m = weight of adsorbent in g
Ce = amount of methylene blue in the bulk solution in mg (Jambulingam *et al.*, 2005).

K_F and 1/n are Freundlich constants related to the adsorption capacity and adsorption intensity respectively. The value of 1/n (less than 1) (Tables 8-11) indicates the favorability of Freundlich adsorption isotherm for methylene blue adsorption from dying industrial effluent for both the adsorbents used in this study.

TABLE -8: Freundlich adsorption isotherm for methylene blue adsorption onto ACM

Time in minutes	Initial conc.of dye mg/L	log Ce	log x/m	Intercept	Slope 1/n	N	Correlation coefficient (r)
10	**600** **800** **1000**	1.4941 1..8215 1.8948	0.4578 0.5276 0.3304	0.9328	-0.3179	-3.1456	-1.0000
20	**600** **800** **1000**	1.4668 1.8075 1.8836	0.4857 0.5526 0.3710	0.6956	-0.1313	-7.6161	-0.3175
30	**600** **800** **1000**	1.4578 1.8007 1.8773	0.4941 0.5646 0.3891	0.6730	-0.1112	-8.9928	-0.2814
40	**600** **800** **1000**	1.4297 1.7937 1.8656	0.5185 0.5763 0.4232	0.6691	-0.0961	-10.4058	-0.2906
50	**600** **800** **1000**	1.4099 1.7867 1.8597	0.5353 0.5888 0.4409	0.6812	-0.0946	-10.3669	-0.3051

TABLE – 9: Freundlich adsorption isotherm for methylene blue adsorption onto ACM

Time in minutes	Initial conc.of dye mg/L	log Ce	log x/m	Intercept	Slope 1/n	n	Correlation coefficient (r)
60	**600** **800** **1000**	1.3979 1.7795 1.8475	0.5428 0.5998 0.4713	0.6289	-0.0542	-18.4501	-0.2043
90	**600** **800** **1000**	1.3654 1.7641 1.8344	0.5646 0.6211 0.4996	0.6328	-0.0429	-23.3100	-0.1788
120	**600** **800** **1000**	1.3541 1.7489 1.8215	0.5717 0.6424 0.5403	0.5396	0.0153	65.3594	0.0737
150	**600** **800** **1000**	1.3424 1.7489 1.8149	0.5786 0.6442 0.5403	0.5805	0.0043	232.5581	0.0212
180	**600** **800** **1000**	1.3424 1.7489 1.8075	0.5786 0.6424 0.5526	0.5548	0.0222	45.0450	0.1221

TABLE – 10: Freundlich adsorption isotherm for methylene blue adsorption onto ACC

Time in minutes	Initial conc. of dye mg/L	log Ce	log x/m	Intercept	Slope 1/n	n	Correlation coefficient (r)
10	**600** **800** **1000**	1.1105 1.4594 1.5877	0.1953 1.0103 1.0877	-1.9630	1.9680	0.5094	0.9830
20	**600** **800** **1000**	1.0457 1.4082 1.5526	0.2121 1.0366 1.1092	-1.7077	1.8672	0.5355	0.9786
30	**600** **800** **1000**	1.0043 1.3692 1.5263	0.2201 1.0530 1.1225	-1.5755	1.8263	0.5475	0.9440
40	**600** **800** **1000**	0.9190 1.3283 1.4996	0.2360 1.0689 1.1361	-1.2330	1.6387	0.6102	0.9749
50	**600** **800** **1000**	0.8061 1.3053 1.4548	0.2513 1.0770 1.1547	-0.9061	1.4585	0.6856	0.9896

TABLE – 11: Freundlich adsorption isotherm for methylene blue adsorption onto ACC

Time in minutes	Initial conc. of dye mg/L	log Ce	log x/m	Intercept	Slope 1/n	n	Correlation coefficient (r)
60	**600** **800** **1000**	0.7403 1.2576 1.4393	0.2586 1.0920 1.1607	-0.7223	1.3610	0.7347	0.9829
90	**600** **800** **1000**	0.6627 1.2014 1.4393	0.2662 1.1072 1.1667	-0.5055	1.2280	0.8143	0.9702
120	**600** **800** **1000**	0.4409 1.1732 1.7050	0.2801 1.1139 1.1847	-0.1637	0.7413	1.3489	0.9352
150	**600** **800** **1000**	0.4409 1.1398 1.3502	0.2801 1.1212 1.1903	-0.1637	1.0518	0.9507	0.9880
180	**600** **800** **1000**	0.4409 1.1398 1.3304	0.2801 1.1212 1.1958	-0.1788	1.0764	0.9290	0.9913

Scanning Electron Microscope Analysis

Scanning electron microscope photographs (magnification 10µm) of the adsorbents ACM and ACC and these adsorbents with adsorbed Methylene blue dye species from a dyeing industrial effluent obtained using Nikon-Epiphot SEM analyzer made in Japan are given in figures 1- 4

Plate 1 I A - The adsorbent prepared from pods of Mimusops Elengi (ACM)
Plate 2 I C - Adsorbent (ACM) with the adsorbed Methylene blue species from a dyeing industrial effluent
Plate 3 II A - The activated commercial carbon adsorbent (ACC)
Plate 4 II C - Activated commercial carbon adsorbent (ACC) with the adsorbed Methylene blue species from a dyeing industrial effluent.

Surface of the photographs (plates 2 and 4) shows the adsorbed methylene blue dye species on the surface of both the adsorbents used in this study.

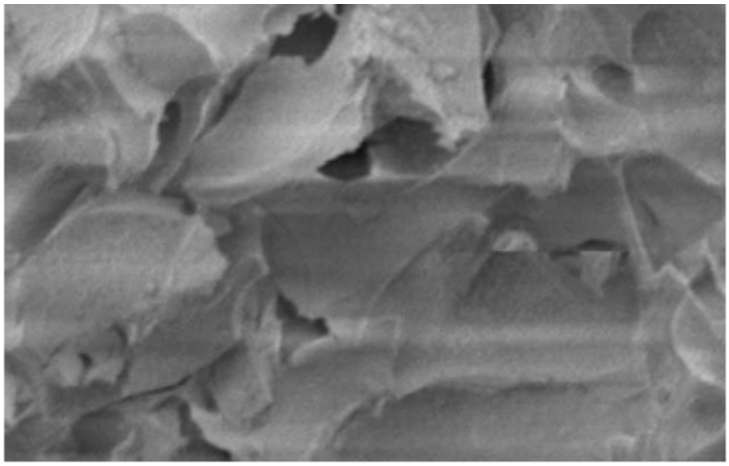

Plate 1: Activated carbon prepared from *Mimusops elengi*

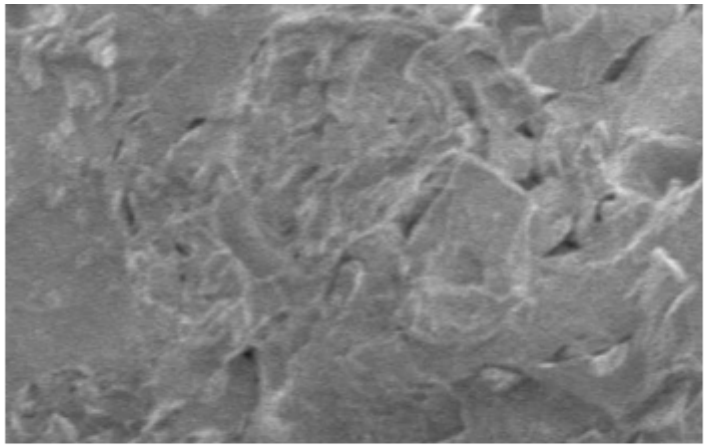

Plate 2: ACM with adsorbed methylene blue species from a dyeing industrial effluent

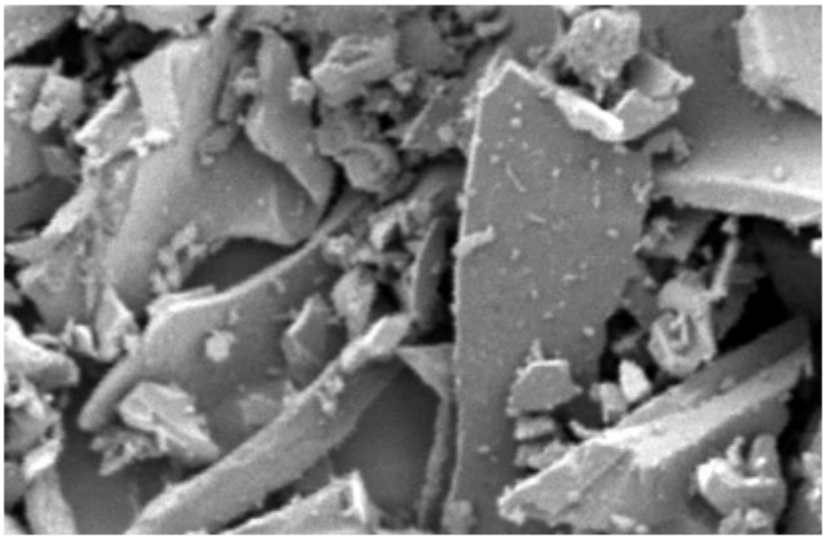

Plate 3: Commercial Activated Carbon

Plate 4: ACC with adsorbed Methylene blue species from a dyeing industrial effluent

CONCLUSION

The carbon derived from the fruit of *Mimusops elengi* can be used as an efficient adsorbent for the removal of methylene blue from a dyeing industrial effluent.

An increase in the percentage removal of Methylene blue from 35.7 to 63.3 % with ACM and from 78.5 to 95.3 % with ACC in 180 minutes of agitation time was noted when the initial concentration of methylene blue obtained from a dyeing industrial effluent was varied from 1000 to 600mg/L. The favourable value of R_L in the Langmuir adsorption data shows the feasibility of the adsorption process. The percentage removal of methylene blue from effluent was greater with the adsorbent ACC compared to that of the adsorbent ACM. This may be due to the grater surface area of the adsorbent ACC (710 m^2/g) compared to the surface area of the adsorbent ACM (340 m^2/g).

However the adsorption of Methylene blue using the low-cost adsorbent prepared from fruit of *Mimusops elengi* is found to be an efficient adsorbent for the removal of methylene blue from a dyeing industrial effluent.

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